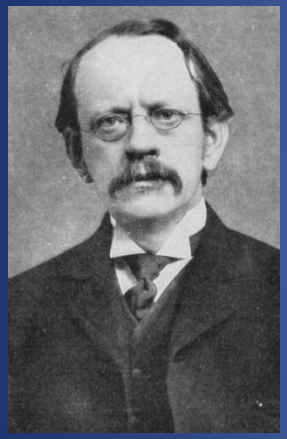
1905: Einstein Introduces Concept of the Photon to Explain Photoelectric Effect

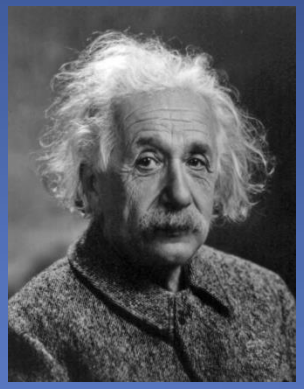
Heinrich Hertz (1857-1894)



J. J. Thomson (1856-1940)

Background

- In 1887 Heinrich Hertz conducted an experiment consisting of a coil and a spark gap. During the course of the experiment Hertz noticed the maximum spark length increased when exposed to ambient light.
- Further experiments showed that a metal plate with a negative charge will lose said charge when exposed to UV light. Also, a neutral plate will become positively charged when exposed to UV light.
- In 1899 J. J. Thomson deduced that the charge the loss of charge in the metal plate was due to the ejection of "corpuscles" (now known as electrons). Also, the rate of electron emission was related to the intensity and color of the light.



Albert Einstein (1879-1955)

$$E = hf$$

Where h is Planck's constant and f is the frequency of light.

$$E = \frac{hc}{\lambda}$$

Where λ is the wavelength of the light.

Theory

- These experiments presented a problem for the common way of thinking about light (Maxwell's wave theory) which predicted that the energy of light would be proportional to the intensity of the radiation.
- In 1905, Albert Einstein solved this problem by describing light as discrete quanta (now called photons). Einstein theorized that these quanta would have an energy equal to the frequency of the light multiplied by a constant (now known as Planck's constant). As such, a photon above the threshold frequency of a material would be able to eject single electron from an atom.

Impact

- This description of light would lead to the quantum revolution in physics.
- The existence of light in quantized form also helped propel the theory of wave-particle duality of light.
- Einstein's description of the quantized nature of light would eventually lead to him winning the Noble Prize in physics in 1921.